SUPPORT DOCUMENT FOR SOLE SOURCE AQUIFER DESIGNATION OF THE GUEMES ISLAND AQUIFER SYSTEM

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INTRODUCTION

Purpose

This document summarizes readily available information and describes the technical and legal basis for the proposed Environmental Protection Agency (EPA) designation of the Guemes Island Aquifer System as a Sole Source Aquifer (SSA). All technical information presented in the document was based on information from the petition unless otherwise referenced. Those interested in more detailed information may consult the references listed at the end of the report.

Sole Source Aquifer Protection Program and Designation Criteria

The Sole Source Aquifer Protection Program is authorized by the Safe Drinking Water Act of 1974 (Public Law 93-523 42 U.S.C. 300 et. seq.). Section 1424(e) of the Safe Drinking Water Act states:

> "If the Administrator determines, on his initiative or upon petition that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the *Federal Register*. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer."

Based on this statutory language, major criteria to be considered by EPA for SSA determinations are:

(1) whether the aquifer is the sole or principal source of drinking water; and

(2) whether contamination of the aquifer would create a significant hazard to public health.

EPA Region 10 has further interpreted the statutory language so that "sole or principal" means that the aquifer must supply at least 50 percent of the drinking water for the aquifer service area (the area above the aquifer including any area that may not be above the aquifer but which is supplied with drinking water from the petitioned SSA). In addition, there should be no alternate drinking water source(s) which can physically, legally, and economically supply all those who depend upon the aquifer for drinking water, should it become contaminated. SSA boundaries are to be delineated based on sound hydrogeologic principles and the best available scientific information.

These criteria are consistent with EPA's Sole Source Aquifer Designation Petitioner Guidance (U.S. EPA, 1987), issued to assist those interested in preparing SSA petitions. The Petitioner Guidance is not binding on EPA decision makers; rather, it describes general EPA policy regarding the preparation and review of SSA petitions.

Since the original statute was enacted, the authority to make SSA determinations has been delegated to EPA Regional Administrators. Although designation determinations are largely based on science-based criteria, Regional Administrators may also consider other factors such as the overall public interest and the net environmental and public health benefits in making an SSA determination.

Following a designation, EPA has the authority to review and approve proposed Federal financially-assisted projects which may pose a significant hazard to public health by contamination of a Sole Source Aquifer. Memorandums of Understanding have been developed between EPA and various Federal funding agencies to help identify projects and focus review efforts on those projects which pose the greatest risk to public health. EPA also coordinates the review of projects with state and local agencies that have a responsibility for ground water quality protection. Their comments are given full consideration in the Federal review process so that the SSA program will support and enhance, rather than duplicate, existing ground water protection measures.

The Safe Drinking Water Act allows EPA to make a designation on its own initiative or in response to a petition. As a matter of general policy, Region 10 evaluates an area for designation only after receiving a complete petition. Petitions may be submitted to EPA by any "person" (meaning any individual, corporation, company, association, partnership, municipality, state, or Federal agency). The petitioner is responsible for providing an appropriate level of hydrogeologic and drinking water usage data to show that the area could qualify for designation.

Petition History

On August 1, 1994, EPA Region 10 received a letter from the President of the Guemes Island Property Owners Association stating that the officers and trustees of the Association were submitting a petition for Sole Source Aquifer designation for the Guemes Island Aquifer System (Guemes Island Property Owners Association, July 1994). By September 1994, an initial review of the petition was conducted and it was determined to be adequate for the purposes of conducting a detailed technical review.

Because SSA petitions are processed by EPA in the order they are received, the Guemes Island technical review was delayed until May 1997 while work associated with an earlier designation proposal was conducted. In July 1997, the Guemes Island technical review was completed. In August 1997, EPA announced that the Guemes Island Aquifer System appeared to meet the criteria for SSA designation. At this time, a public participation process was initiated to inform and seek public comment from the residents and property owners of Guemes Island, as well as other interested and affected parties.

GENERAL DESCRIPTION OF GUEMES ISLAND

Geography

Guemes Island is a small triangular island in Puget Sound, which is located north of the City of Anacortes in townships 35 and 36 of the western part of Skagit County, Washington (Figure 1). It is centered around 122^{o} 37' longitude and 48^{o} 33' latitude. The total area of the island is approximately 8.2 square miles. The southeastern part of Guemes Island is hilly and composed of bedrock and fractured rock; the remainder is gently rolling and overlain by glacial drift. The southeastern bedrock tip is named the Southeast Point. Public access to the island is limited to a county-operated ferry, which runs between Anacortes and Guemes Island (Kahle and Olsen, 1995).

Climate

Guemes Island has a temperate marine climate with distinct wet and dry seasons. The summer temperatures generally remain below 75 degrees F, and extended periods of sub-freezing temperatures during the winter are unusual. Precipitation falls predominantly as rain which averages about 25 inches per year. There is a distinct precipitation gradient across the island, with average values of approximately 22 inches per year on the southwestern part of the island to approximately 28 inches per year on the easternmost part (Kahle and Olsen, 1995).

Population

The year-round population of the island is approximately 540, with a summer population which nears 2,200 (Kahle and Olsen, 1995). Much of the island has a rural

setting with most of the population concentrated along the coast. The most populated areas are West Beach, Indian Village, North Beach, Seaway Hollow, Holiday Hideaway, South Shore, and Kelly's Point.

Economy

Commerce and industry are mostly limited to a small tourist resort at North Beach. Other businesses include a gravel pit and several small businesses related to arts and crafts, construction trades, or livestock.

HYDROGEOLOGY

All of the following information is excerpted directly from Hydrogeology and Quality of Ground water on Guemes Island, Skagit County, Washington, U.S. Geological Survey (USGS) Water-Resources Investigations Report 94-4236, by Kahle and Olsen, 1995.

Geology and Aquifer Use

There are eight distinct geologic units present on Guemes Island (Figure 2): consolidated bedrock, Double Bluff Drift, Whidbey Formation, Vashon advance outwash, Vashon till, Everson drift, peat, and beach deposits. There is considerable variation in thickness of individual units, and not all units are necessarily present at any one location (Kahle and Olsen, 1995). Figure 3 shows an example of the geology and stratigraphy under a representative cross-section of the island.

Bedrock is exposed only on the southeastern end of the island and is composed of locally fractured igneous and fine-grained marine sedimentary rocks of Middle Jurassic to Early Cretaceous age. Except where the bedrock is exposed at land surface, depth to bedrock from the land surface (thickness of the unconsolidated deposits) is largely unknown, but ranges from 0 feet to greater than 300 feet according to a map of thickness of unconsolidated deposits in the Puget Sound Lowland (M.A. Jones, 1996). Locally it can yield water where the rocks are faulted or fractured, but yields are generally small. As of 1991, only about five wells tapped this unit (T. Olsen, 1997, oral comm.).

The Double Bluff Drift is composed of till, glacio-marine drift, glacio-fluvial sand and gravel, and glacio-lacustrine silt, and represents the principal aquifer on the island. It is the oldest, deepest, and most productive unconsolidated deposit that has been encountered by drilling on Guemes Island. Total thickness of the unit is unknown, because drilling generally stops once the unit is penetrated sufficiently to yield water at required rates. It is exposed at or near sea level in sea cliffs on the northern tip of the island and at two locations along the southern shoreline.

The Whidbey Formation consists of floodplain clay, silt, peat, and lenses of sand that accumulated on top of the Double Bluff Drift during the last major interglacial period in the Puget Sound Lowland. The unit is generally poorly permeable, but it locally contains productive sand lenses. There are at least 17 wells that tap these lenses. The unit occurs at depth throughout much of the island and is commonly 40 to 130 feet thick. The Whidbey Formation is exposed only in sea cliffs on Guemes Island.

Three deposits of the Vashon Stade of the Fraser Glaciation are found on Guemes Island: Vashon advance outwash, Vashon till, and Everson drift. Vashon advance outwash consists of sand and gravel and is exposed along the western edge of Guemes Island and in a small gravel pit located near the north-central part of the island where overlying till has been removed. It commonly ranges in thickness from 40 to 80 feet, with a maximum thickness of approximately 120 feet on the northern part of the island. The Vashon advance outwash is not present over the entire island, but occurs in two large areas on the island. Vashon till is a compact mixture of clay, silt, sand, gravel, and boulders that occurs at land surface over much of the island. Everson drift consists of pebbly clay and silt referred to as glaciomarine drift, and occurs mostly in low-lying areas. The Vashon till and Everson drift are considered together to represent a surficial confining unit. Thicknesses range from 20 feet to more than 200 feet in the south-central part of the island. At least five wells are completed in productive lenses of this unit.

Two units are still being deposited on Guemes Island: peat and beach deposits. Peat, composed of partially decomposed and disintegrated organic matter, occurs in poorly drained low-lying areas. Beach deposits consist of sand and gravel that were weathered from sea bluffs or that has accumulated above high tide as a result of long shore drift, the wave-generated movement of sand or gravel parallel to the shore. Large beach deposits can be found at North Beach and West Beach, with thicknesses ranging from 10 to 20 feet. At least two wells are completed in this unit.

USGS categorized the geologic units into six hydrogeologic units, based on their areal extent and water-yielding properties. The units are: beach aquifer, surficial confining unit, Vashon aquifer, Whidbey confining unit, Double Bluff aquifer, and bedrock confining unit. Except for the surficial confining unit, the hydrogeologic units are essentially equivalent to the geologic units for which they are named.

Hydraulic Conductivity

The following information is taken from the petition (Guemes Island Property Owners Association, 1994).

Estimates of horizontal hydraulic conductivity were made by USGS for the principal hydrogeologic units using specific-capacity data as recorded on drillers' logs. The values are summarized in Table 1. Specific capacity data were unavailable for the beach deposit and bedrock units. No areal patterns were detected in the distribution of

horizontal hydraulic conductivity values in the Vashon advance outwash and Double Bluff aquifers. The median values for the two main aquifers, 43 ft/day for the Vashon and 68 ft/day for Double Bluff, are quite similar. The median value for the confining Whidbey Formation is 1.6 ft/day. The median value of 23 ft/day for the surficial confining unit (Everson drift and Vashon till) may be skewed due to the small data set (2 wells), and the fact that data for confining beds are generally only available for those areas where lenses of productive material exist. Hydraulic conductivity values for beach deposits are expected to be similar to those for the Vashon advance outwash and the Double Bluff aquifers.

No data were available to estimate vertical hydraulic conductivity of the hydrogeologic units on Guemes Island. Other studies around Puget Sound indicate that in glacial materials, vertical hydraulic conductivity is generally orders of magnitudes less than horizontal hydraulic conductivity.

Ground Water Flow System

Ground water data from wells on the island indicate that the ground water flow system under Guemes Island is similar to ground water systems present under most islands. Figure 4 is a simplified conceptual model of hydrologic conditions on the island. Precipitation falls on the island as rain or snow, and either runs off to roadside drainage ditches, ponds or marshes, or directly back into the sea, and/or infiltrates the ground. Part of the precipitation is evaporated back to the atmosphere. Some of the water that enters the ground continues to percolate downward to the water table as recharge to the ground water system. The water then discharges to ponds, springs, wells, and to Puget Sound.

An estimate of 6 inches of freshwater recharge to the Guemes Island ground water system was made by USGS by correlating the hydrogeologic units and precipitation on Guemes with similar hydrogeologic settings in southwestern King County where recharge analyses and modeling was conducted. Recharge for Guemes Island is relatively small compared to other areas of western Washington because of the island's lower average annual precipitation and the lower permeabilities of its surficial geologic materials (Kahle and Olsen, 1995).

Fresh ground water under the island most likely occurs as a lens-shaped body that "floats" on top of the more dense, saline water. The thickness of this lens is usually the greatest near the center of islands, and decreases toward the coast. Ground water in an island environment generally moves radially from its area of recharge toward the coast. The boundary between the fresh water and saline water is commonly referred to as the freshwater-seawater interface, which represents an area of mixing of the two waters.

To date, the most comprehensive water level data available only allow for point data to be represented. There are not enough correlatable water levels on the island

available to construct water level contour maps. Without water level contours, direction of ground water flow on the island for each of the hydrologic units can only be grossly estimated from maps representing ranges of water level altitudes. Figures 5 and 6 show water level altitudes measured in October 1991 for the Double Bluff and Vashon aquifers, along with 2-year hydrographs. Water levels in the Double Bluff aquifer were generally 13 to 30 feet above sea level in the central part of the island and generally less than 13 feet in near-shore areas. Water levels in the overlying Vashon aquifer were generally 61 to 80 feet above sea level near the central part of the island and less than 30 feet in near-shore areas.

Ground Water Quality and Vulnerability

Ground water quality on Guemes Island is considered to be generally of good quality. Seawater intrusion (high chlorides) and nitrates are contaminants of the most concern. The aquifer system underlying the island is considered to be vulnerable to contamination due to the highly heterogeneous nature of the sand and gravels making up the aquifers, and the inconsistent confining nature of the surficial confining unit and the Whidbey confining unit.

High chloride concentrations in well water on the island are due to either the presence of relict seawater in aquifer materials, or seawater moving inward from Puget Sound (seawater intrusion). Uncontaminated ground water in most coastal areas of Washington generally contains less than 10 mg/L of chloride, whereas seawater contains about 19,000 mg/L of chloride. A chloride concentration above 100 milligram per liter is considered to indicate seawater intrusion (Kahle and Olsen, 1995). As early as May 1967, a chloride concentration of 315 mg/L was reported for a well on North Beach. In June 1987, the chloride concentration of that same well was 270 mg/L, while a well close to the northern tip of the island had a concentration of 630 mg/L (Dion and Sumioka, 1984).

In August of 1987, the Northwest Regional Office of the Washington Department of Ecology initiated a reconnaissance ground water study on the island. The study indicates that there was no arsenic contamination, but some seawater intrusion (or relict seawater in aquifer materials) was present in near-shore areas and at the northern tip of the island. A correlation between pumpage and chloride concentration was documented for two water systems.

Chloride concentrations were also measured in wells on the island during a 1991 USGS study of the island ground water (Kahle and Olsen, 1995). Figure 7 shows the concentrations which range between 10 mg/L to 800 mg/L. Concerning the probability of extensive seawater intrusion occurring in the island, USGS states:

> "From an island perspective, significant seawater intrusion is unlikely at the present time given the small quantity of ground-water discharge that goes to pumping wells. However, the geographic distribution of the

pumping wells is a critical factor in seawater intrusion. Excessive ground-water withdrawal in a near-shore area can cause large local movement of the freshwater-seawater interface especially if the aquifer is thin. The degree of seawater intrusion depends on the proximity of the well's opening to the freshwater-seawater interface, the rates of recharge and pumping, and the local permeability of the hydrogeologic unit."

Nitrate is considered to be a health threat at levels above 10 mg/L. The USGS study found nitrates ranged from <0.05 mg/L to 6.8 mg/L in 24 wells on the island. Two areas appear to have nitrate concentrations generally exceeding 1.0 mg/L: near Indian Village and along North Beach (Kahle and Olsen, 1995). Concentrations in most samples were 1.0 mg/L or less. Nitrates in ground water can originate from septic tanks, animal wastes, and fertilizer.

Trace concentrations of volatile organic compounds were detected in three of five wells sampled during the USGS effort (Kahle and Olsen, 1995). Trichloromethane, 1,1,1-Trichloroethane, and benzene were each detected in one of three shallow wells (26 to 64 feet). The other two wells were relatively deep (90 and 114 feet). The source of these compounds is unknown. Methylene blue active substances (MBA) and boron were detected in two of 12 wells sampled. Nitrates were present in the same wells, indicating septic systems as a likely contaminant. Fecal-coliform bacteria were present in one well out of 24 sampled.

AQUIFER BOUNDARIES

The Guemes Island Sole Source Aquifer boundaries were determined by following aquifer definitions from EPA Guidance (EPA, 1987). The Guidance states that petitioners may request designation for part of an aquifer, an entire aquifer, or an aquifer system. This follows from the definition of an aquifer as a geological formation, group of formations, or part of a formation capable of yielding significant quantities of water to a well or spring. A petitioner can request designation for part of an aquifer if that portion is hydrogeologically separated from the rest of the aquifer. A petitioner can also request designation for an aquifer system to the extent that all aquifers in the system are hydrogeologically connected.

The Guemes Island Sole Source Aquifer boundaries are representative of an aquifer system that encompasses the entire Guemes Island area (Figure 8). The aquifer system is bounded on all sides by Puget Sound. The vertical extent of the aquifer system at depth includes all potable water-bearing geologic units underlying the island, including both the unconsolidated glacial deposits and the bedrock unit.

SOURCES OF DRINKING WATER

Ground water is the sole source of freshwater for Guemes Island and there is no potential for development of surface water sources (Kahle and Olsen, 1995). This satisfies EPA designation criteria that the aquifer system is the sole or principal drinking water source for the area, and that contamination of the aquifer system would create a significant hazard to public health (as there are no alternate drinking water sources which can physically, legally, and economically supply all those who depend upon the aquifer system for drinking water). Estimated ground water withdrawals on the island during 1992 for public, private, and livestock uses are shown in Table 2.

CONCLUSIONS

The Guemes Island Aquifer System appears to meet the criteria for designation as a Sole Source Aquifer under Section 1424(e) of the Safe Drinking Water Act. Boundaries have been defined based on sound hydrogeologic principles; the aquifer system is the sole or principal source of drinking water for the area; and there are no feasible alternate sources of drinking water which could replace the aquifer system should it become contaminated.

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